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CORN-BASED PLASTICS:
WAVE OF THE FUTURE OR A RIPPLE THAT DEGRADES?

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Corn-based plastics present a potentially compatible interface between two groups that traditionally view each other with suspicion: farmers and environmentalist. If successful, biodegradable corn-based plastics can reduce the corn surplus, a problem throughout the 1980s, and help solve the solid waste problem. During the 1990s, over half of U.S. cities may run out of landfill space, a future foreshadowed by the 162 day-odyssey of an Islip, New York garbage barge (1).

Plastic waste has been signalled out as a major culprit. It is the fastest growing component of solid waste: from less than three percent in 1960 (2) to a projected 15 percent by turn of the century (3). Compounding the problems created by this rapid growth, plastics are estimated to take up to 400 years to degrade (4).

Concern over plastic waste has prodded governments to act. Suffolk county, New York will ban polyethylene grocery sacks and polystyrene and polyvinyl chloride fast food packaging as of July 1989 (2). In July 1990, Minneapolis, Minnesota will require that food packaging be recycled, reused, or degrade naturally, except if no easy alternative exists (3). Berkeley, California and six states also have passed laws concerning non-degradable plastics. Thirteen other states are considering legislation. Illustrating international concern, Italy will require degradable packaging and wrapping after 1989 (5).

This legislative activity has created a market for corn-based plastics. However, it must compete against photodegradable and recycled plastics as potential solutions. Each of these options face considerable technological and economic constraints. Based on a discussion of these constraints, conclusions are reached about the current market potential of corn-based plastics and recommendations are drawn for market development activities.

BIODEGRADABLE PLASTICS

Although conventional petrochemical plastics will eventually biodegrade, the term, "biodegradable plastics," is usually reserved for plastics that contain starch derived from a farm commodity. Theoretically, plastics can be manufactured from 100 percent of any commodity starch. However, current economic considerations dictate use of a mixture that is six percent corn starch and ninety-four percent conventional petrochemical resin.

Biological organisms degrade the corn starch in a relatively short time period, leaving holes in the remaining petrochemical plastic. As with traditional petrochemical plastics, 400 years may be required for biodegradation of the petrochemical component of a six percent corn starch plastic (6). To take advantage of the increased surface area left by decay of the corn starch, a chemical catalyst is added to the starch - petrochemical resin mixture (4). It is this combination of starch and chemical catalyst that increases the rate of decay of the plastic product.

The most common biodegradable plastic products are agricultural mulch films, which are used primarily to deter weed growth in truck crops, and plastic bags. Currently, biodegradable plastic bags cost eight to twenty percent more at the manufacturer level than conventional plastic bags (7). This difference may decline as more biodegradable bags are produced due to economies of larger production. On the other hand, starch reduces the plastic product's strength (8). The more starch used, the weaker the product becomes. Product strength can be increased by making the product thicker, but cost increases (8).

Several concerns confront biodegradable plastics. One is the unpredictability of degradation in a landfill. For example, a study found that a piece of supposedly, non-degradable plastic had decomposed 50 percent in 20 years while a chicken leg next to it still had meat left on the bone (9). The unpredictability results from the complex interrelationships among the 36 variables that affect degradation (9). An important variable is the lining of landfills to prevent seepage into water supplies. This slows air and water movement and, thus, biodegradation. Consequently, the microenvironment of a landfill may substantially retard the degradation of corn-based plastics.

A second concern is that residues left by degradation of petrochemical plastics, whatever the type of petrochemical plastic, may be toxic to the environment. Measurement of this concern is difficult because most plastic waste has degraded little over the relatively short period of time that plastic products have been used. The potentially more rapid decay of corn-based plastics imparts a more immediate nature to this concern. Furthermore, the chemical catalyst used in biodegradable plastics may be toxic to the environment (4).

Another concern is the volatility of corn starch prices. Between 1978 and 1988, the standard deviation of annual corn starch prices relative to average annual price was 46 percent. For petroleum, the comparable ratio was 29 percent. Manufacturers generally prefer inputs with the greater price stability.

PHOTODEGRADABLE PLASTICS

A chemical can be added to petrochemical plastic resins to trigger degradation once the chemical has been exposed to ultraviolet light for a given period of time. These plastics can be targeted to degrade over any length of time between 30 days and one year (10).

Depending on end use, photodegradable plastic products range from no more expensive to 10 percent more expensive than conventional plastics (10). The higher cost for certain products reflects the need to use more plastic resin to compensate for the loss of product strength caused by the use of the photodegradable chemical (11).

Photodegradable plastics offer a potential solution for litter scattered on the ground. However, ultraviolet light is readily absorbed by water and earth. Thus, unlike biodegradable plastics, photodegradable plastics probably possess limited ability to decompose in landfills and oceans. Photodegradable plastics may degrade in landfills if they are exposed to ultraviolet light for 72 hours before being placed in the landfill (10), but this claim awaits proof.

RECYCLABLE PRODUCT

Use of recycled plastics is currently limited by questions about the durability of recycled plastics after repeated reheating and remolding. In addition, collection costs are high because of the use-and-discard mentality of Americans and the wide variety of plastic resins. The latter means plastic waste must be sorted into resin groups. Furthermore, many plastic products are made from two or more resins. No economically competitive process currently exists to separate mixed-resin plastics into their constituent resins (2). Thus, these plastics can be recycled only into dark-colored, low-end products that do not require a smooth finish. Markets for these products, such as plastic filler and wood, are limited (2).

Despite these constraints, economic incentives currently exist for recycling some plastics. For example, recycled polyester (PET) and polyethylene sell for about half the price of virgin resins (12). PET and polyethylene, the most commonly recycled resins, are used primarily in soft drink containers and packaging. Just over one percent (222 million pounds) of these resins were recycled in 1987 (12). Given the constraints on recycled plastics, potential market share is estimated at only four percent (2,12).

To aid identification of resin types, the plastics industry has instituted a voluntary labeling system (13). However, research must address the mixed-resin and durability problems. Furthermore, given current technology, recycling of biodegradable or photodegradable plastics is impossible. Thus, for a given product, degradation and recycling are mutually exclusive. A potentially novel technological solution to the problems with recycling is the retrieval of the oil contained in plastic products (14).

CONCLUSIONS, MARKET PROJECTIONS, AND SUGGESTIONS

Based on the above discussion, the following conclusions can be drawn:

1) Given current technology, corn-based plastics are not priced competitively with traditional petrochemical plastics. Thus, their market depends on legislation.

2) Photodegradable plastics and recycled plastics are priced competitively with traditional petrochemical plastics, but in only limited markets and uses.

3) Determination of the eventual relative competitiveness of corn-based plastics with photodegradable or recycled plastics on economic or environmental grounds requires firm-specific propriety information, and, therefore, is not possible.

4) Biodegradable, photodegradable, and recycled plastics can not solve the landfill problem because plastics make up only about 10 percent of current landfill waste. The best these options can do is buy time. Recycling appears to buy the most time because biodegradable and photodegradable plastics require landfill space to degrade and because of the unpredictability of degradation in a landfill.

5) Given current technology, corn-based plastics probably will be used only for plastic packaging due to concerns over its strength and durability.

In 1988, 13 billion pounds of plastic resins were used for packaging. If a six percent corn starch mixture was used for all plastic packaging, approximately 25 million bushels of corn or about 0.3 percent of 1987 crop year disappearance (15) would be required. Using a reasonable assumption of a -0.4 for total demand elasticity of corn, 1.5 to 3.0 cents would be added to the market price of corn. This increase translates into $100 to $225 million dollars of additional income to U.S. corn producers.

Unfortunately, this estimate is probably high. First, packaging is an important use for recycled plastics. As discussed above, recycled plastics have an economic advantage for certain uses. Second, no application has been received by the Food and Drug Administration for use of biodegradable plastics in food packaging. The ability of starch to absorb water may mean that biodegradable plastics could be unsafe for packaging any food product that contains water. Absorption of water may break down the biodegradable plastic, permitting infestation by harmful organisms.

The preceding discussion suggests caution in estimating the current market for biodegradable plastics. Furthermore, these markets depends on legislation. Thus, to maximize the potential of legislated markets, farm organizations will need to develop a workable coalition with environmentalist, a group they have usually viewed with suspicion.

To increase market potential beyond legislated markets, the following research and/or actions are needed:

- Strength of biodegradable plastics must be increased in an economically competitive manner,
- Predictability of degradation in landfills must be enhanced,
- Biodegradable plastics must be made compatible with recycling, and
- Petrochemical plastic manufacturers must be convinced that institutions and strategies can be adopted to reduce the potentially negative impact of farm commodity price volatility. Such an adaptation should be possible since food manufacturers and exporters have successfully adopted to the price volatility of farm commodities while plastic manufacturers have already adopted to the substantial volatility in petroleum prices. Nevertheless, initially, corn farmers may find it useful to provide a corn reserve earmarked for use by plastic manufacturers when supplies become low.

REFERENCES

1) Browne, Malcom W., "World Threat of Plastics Trash Defies Technological Solution", The New York Times, September 4, 1987, p.6.

2) Crawford, Mark, "There's (Plastic) Gold in Thar Landfills", Science, Vol. 486, no. 3, May 1987, pg. 44-47.

3) Schmidt, William E., "Ban on Plastics Wins Approval in Minneapolis", The New York Times, April 1, 1989, pp 1 and 7.

4) Gould, J. Michael, U. S. Department of Agriculture, telephone interview, April 5, 1989.

5) Henderson, Pam Cole, "Pollution Solution, Can Corn Really Help America Dig Out From Under the Heap?", Top Producer, February 1989, Vol. 6 No. 2, pg. 38-40.

6) Gould, J.Michael, S. H. Gordon, L. B. Dexter, and C. L. Swansan, "Microbial Degradation of Plastics Containing Starch", Proceeding of the Corn Utilization Conference II, November 17-18.

7) Markrauer, George A., President and Executive Officer, Amko Plastics, telephone interview, April 5, 1989.

8) Markrauer, George A., "Comments Before Committee on Governmental Affairs, U. S. Senate, September 20, 1988.17.

9) Kinman, Reily, Professor, Department of Environmental Engineering, University of Cincinnati, telephone interview, March 14, 1989.

10) Lantinberg, Sheldon, President of Plastagone Company, telephone interview, December 2, 1988.

11) Heppenheimer, T. A., "Plastic Makers Clean Up From Litter", High Technology Business, August 1988, pp. 30-32.

12) Bennett, Robert A., "Recycled Plastics: End-Use Market Identification", seminar paper, November 17 1988.

13) Bennett, Robert A., Associate Dean, Collage of Engineering, University of Toledo, telephone interview, February 16, 1989.

14) Feldman, David, "Legestion Relevant to Biodegradable Polymers", Proceedings of Corn Utilization Conference II, November 17-18, 1988.

15) U.S. Department of Agriculture, Agricultural Outlook, AO-150, March 1989, pp. 49.